

deterrent to piracy. Such systems are currently in use in Europe and have not yet been breached.

By the end of 1991, T3/S2 was convinced that all of the proposed all-digital ATV simulcast systems could accommodate a conditional-access system based on a replaceable security module that would meet all six general requirements for system security listed under Desirable Attributes in Document T3/180. Furthermore, we agreed that there were no technical roadblocks to developing a voluntary conditional-access standard for ATV.

Should the FCC choose an analog ATV system, all of the above discussion applies except that the scrambling would use line permutation and/or rotation with a sufficiently large number of permutations and/or cut points to satisfy the "unrecognizability" and "impossibility of recovery by inspection" requirements. T3/S2 has assumed that the FCC most probably will choose a digital ATV system for terrestrial broadcast.

T3/S2 also concluded that it is possible to design and standardize a conditional-access system that meets all of the other requirements for Desirable Attributes, as well as the Desirable Features and Other Considerations, listed in Document T3/180. The subscriber hardware for such a standardized conditional-access system could be contained in a back-of-the-set box connected to an appropriate ATV receiver baseband signal interface, or alternatively, except for the replaceable security module, could be built into the ATV receiver. If conditional-access hardware is built into the ATV receiver, a separate interface (not the baseband signal interface) would be required to accommodate the replaceable security module and still another interface would be needed to provide signals to an upstream data link to order pay-per-view programs.

The vast majority of those who participated in the work of T3/S2 believe that the adoption of an all-digital ATV standard and the concept of a replaceable security module make it possible to satisfy all of the security and operational requirements for conditional access with a single voluntary industry standard. This same majority believes that every effort should be made on the part of the various delivery media to reach agreement on such a standard. However, this is no small task. Aside from agreeing on the scrambling methodology, encryption algorithm, replaceable security module interface, and related technical details required to meet the Desirable Attributes listed in Document T3/180, there must also be agreement on how the Desirable Features and Other Considerations in Document T3/180 will be implemented, at least to the extent that they impact the subscriber hardware. These functions include ordering, billing, number of tiers, program tracking, pay-per-view ordering, multiple operator use and control, etc.

Although a significant cooperative effort on the part of many industry segments, some of which traditionally compete with one another, would be required to develop the details of a single voluntary conditional-access standard, the majority of the participants in T3/S2 believe that the advantages of having such a standard justify the effort. The lack of any demonstrated technical roadblocks and the long-range advantages of cost and convenience to both the consumer and the program provider are compelling arguments for a single conditional-access standard.

A minority of our participants, however, believe that the adoption of a single voluntary conditional-access standard may not be possible, and that even if a voluntary standard is adopted, it may not find widespread use. These participants are concerned that the high level of cooperation needed among many companies in a number of industries may not be achievable. They also cite lingering concerns about piracy, despite the use of a replaceable security module, pointing out that a ubiquitous standard provides a tremendous economic incentive to a pirate. They also point out that the use of multiple standards will allow simpler and potentially less expensive conditional-access systems to be used in small markets where the subscriber universe is not large enough to attract a pirate. They also argue that multiple conditional-access standards will allow flexibility in meeting the requirements for Desirable Features and Other Considerations listed in Document T3/180.

Regardless of whether a single voluntary conditional-access standard can be agreed to, there was unanimous agreement within T3/S2 about the importance of providing a digital baseband interface on all ATV receivers and VCR's. Such an interface, discussed below, is an achievable key step to providing user friendliness and is an important first step towards a single voluntary conditional-access standard. A digital baseband interface on ATV receivers and VCR's will permit descramblers to be implemented as back-of-the-set boxes preserving the tuning, remote control, programmability and other features of the consumer's ATV receiver and VCR. To avoid the need for set-top converters, it is essential that ATV receivers and VCR's have an interface that will deliver as output and accept as input the source-coded baseband digital video, audio and data signal. In a Cable TV environment, the subscriber will be able to use his tuner, remote control and other ATV receiver functions, and in the case of scrambled programming, a back-of-the-set box will receive the scrambled, source-coded digital baseband signal from the interface, descramble the signal and return a clear source-coded digital baseband signal to the receiver for decompression and display. In the case of a VCR, the interface will perform in like fashion with another back-of-the-VCR box. These back-of-the-unit boxes will of course, have an interface for their replaceable security modules.

Provision of a digital baseband interface on ATV receivers and VCR's is an essential first step to a voluntary, single, conditional-access standard in any case. Even with agreement on a single conditional-access standard, it is not likely that receiver manufacturers would choose to build the necessary scrambling hardware

into ATV receivers until a sufficiently large fraction of the market requires such hardware. If and when a single, voluntary, conditional-access standard can be agreed to and marketplace factors dictate that the descrambling hardware be built into the ATV receiver, the interfaces for the replaceable security module and any upstream communication will become receiver interfaces.

#### D. ATV Receiver Interface

With respect to the television receiver interface issues, T3/S2 believed from the outset that the EIA Receiver Interface Subcommittee (now R4.1) had them well in hand. During 1989 and 1990, we reviewed drafts of their reports at various stages and provided our comments. We held a joint meeting with them in April of 1990 and the Chairman of T3/S2 has been attending their meetings as an active participant since early 1991. Initially, R4.1 developed a generic model of possible ATV receiver interfaces. Recently the Committee has focussed more specifically on baseband signal and control interfaces. Although precise details of the interfaces must await the choice of a terrestrial broadcast standard by the FCC, R4.1 has identified four possible interfaces: A baseband analog interface which will be luminance and two color difference signals; a baseband digital interface (assuming a digital ATV standard is selected by the FCC) which will be source-coded digital video, audio and data; a control interface to pass receiver status to other devices, receive status from other devices and to allow user inputs (either directly to the TV or via remote control) to be passed to other devices, e.g., to order pay-per-view programs via a modem or other up-stream communications link; and a conditional-access interface to accommodate a replaceable security module at such time that the conditional-access hardware is built into the ATV receiver.

In early February of 1992 the EIA R4.1 Committee distributed a questionnaire concerning these four possible interfaces to a wide cross-section of the television industry. The responses to the questionnaire are being analyzed and, along with inputs from T3/S2, T3/S3, PSWP4 and other industry groups, will help to define appropriate interface ports that can lead to EIA recommendations for voluntary standards for television receiver manufacturers.

The baseband digital interface and the control interface which are separate logical interfaces, but may be carried on a single physical connector, will permit a user-friendly implementation of conditional access even with multiple standards (albeit possibly requiring multiple back-of-the-set boxes) and is, in any event, an essential first step to achieve a single, voluntary, conditional-access standard. The baseband digital interface will provide the scrambled signal to the back-of-the-set box and permit the descrambled signal to be returned to the receiver for decompression and display. The control interface will allow user inputs to the ATV receiver (either direct or by remote control) to be passed to the back-of-the-set box. At some future

time, if conditional-access hardware is built into ATV receivers and VCR's, the replaceable security module interface will become a receiver interface.

The EIA R4.1 Receiver Interface Subcommittee is well aware of the requirements for these interfaces and is following a path to define them such that they will meet the requirements.

#### E. DBS

Beginning at our March 7, 1990 meeting, T3/S2 began to study satellite (DBS) delivery of ATV programming to consumers. We understood that the SBCA was planning to distribute a questionnaire to present and prospective satellite programmers concerning ATV-related issues. We established a liaison with SBCA to initiate a cooperative effort and avoid duplication of work. It quickly became clear that the conditional-access issues for DBS and Cable TV were substantially the same, except possibly for data capacity requirements to address a larger universe of subscribers from a single transmission point in the case of DBS.

Although DBS transmission of ATV will of necessity require a separate receiver, if, as seems likely, DBS chooses the same baseband digital video, audio and data signal format used for terrestrial broadcast of ATV, the recovered, source-coded, compressed digital baseband signal can be delivered directly to the digital baseband interface of the ATV receiver for decompression and display. Although it is not essential that DBS systems employ the same conditional-access system used by Cable TV, it would seem desirable that they did. First, it would permit economies of scale for hardware components and second, it would permit building an ATV receiver that tuned DBS signals as well as Cable TV and terrestrial broadcast signals and employed common descrambling hardware. It should be noted that combined DBS and terrestrial NTSC receivers are currently marketed in Japan.

A major difference between DBS and Cable TV is the different modulation method used by DBS. All four of the digital ATV system proponents plan to use QPSK for satellite transmission, but they have not provided specific details. T3/S2 concluded that the proponents of ATV systems should be asked how they proposed to deliver ATV signals over satellites, and that it would be desirable to conduct comparative satellite delivery tests of the proposed ATV systems. PSWP4 had developed a skeleton test plan for satellite transmission and T3/S2 volunteered to convert this into a specific test plan, if the SBCA could put a test program in place. During the period from December, 1990 to July, 1991, there was an ongoing dialog between T3/S2, SBCA and ATTC. In July, 1991 SBCA created a Working Group on Satellite Testing of ATV Systems, which first met on July 17, 1991. By early December of 1991, the Working Group developed a Conceptual Test Plan for Satellite Delivery of ATV. This plan differed significantly from the earlier PSWP4 plan because of the change from analog systems to all-digital systems.

Later in December of 1991, the SBCA Working Group initiated discussions with PSWP4 and in January, 1992, the Working Group became a sub-group of PSWP4. The present plan is to conduct a theoretical evaluation of the proposed ATV systems based on information supplied by the proponents about how they propose to deliver ATV by satellite.

F. Other Alternate Media

Fiber Optic Delivery of ATV

There has been much said about the delivery of ATV signals to consumers by telephone companies using fiber optic links. Digital delivery as a part of the Broadband Integrated Services Digital Network (BISDN) is frequently mentioned. Since the question of ATV signal delivery by telephone companies compared with delivery by traditional Cable system operators is a political and/or regulatory issue and not a technical issue, T3/S2 has concentrated only on the technology employed to deliver the ATV signals to the consumer and not on the business entities providing the delivery. The tests conducted at the ATTC by Cable Labs included both coaxial cable and fiber optic link technology for the delivery of the various proposed ATV signal formats to consumers. Therefore the necessary technical information for the comparative evaluation of the proposed ATV systems when transmitted over broadband fiber optic links has been developed and can be applied to the standards decision process.

Should switched fiber optic systems carrying one or a few ATV channels come into use by telephone companies, for example, T3/S2 believes that they too should employ substantially the same baseband signal format selected by the FCC for terrestrial broadcast. As in the case of DBS, the modulation method might be different, but after selection and demodulation the recovered source-coded, compressed digital signal can be delivered directly to the digital baseband interface of the ATV receiver for decompression and display. Although it might not be necessary to scramble signals in a switched system to provide for conditional access, if such systems do use scrambled signals, it would seem desirable to employ the same scrambling and conditional-access standard used by Cable TV and other media.

Microwave Media

T3/S2 has not conducted an extensive study relating to the delivery of ATV signals by MDS, MMDS or ITFS systems. However, their similarity to Cable TV and the fact that, with the use of simple block converters, they can be tuned directly by TV receivers, argues strongly that these systems use the same signal format and conditional-access standards as Cable TV.

### Pre-Recorded Media

With respect to pre-recorded media, we discussed this issue at several of our meetings and in particular discussed it during our April 19, 1990 joint meeting with the EIA Receiver Interface Subcommittee. Our conclusion is that voluntary standards for pre-recorded media will evolve naturally once terrestrial broadcast and alternate media transmission standards are established. The EIA has given this matter some consideration, and they also believe that it is premature to be specific about signal formats for pre-recorded media. It is likely that ATV VCR's and Video Discs will simply record the source-coded, compressed digital signal (with appropriate channel coding and modulation method, of course), but the need to do "tricks" (slow motion, still frame, search, etc.) may be a complicating factor. If the source-coded digital baseband signal is the signal that is exchanged between an ATV receiver and VCR, the same logical interface used for back-of-the-set conditional-access hardware would also serve as the VCR interface.

### Digital Services

Our sister Specialist Group T3/S3 has studied this subject and made specific recommendations concerning audio services and other digital services including captioning, teletext, etc. See T3/S3 Report (Document T3/186).

A key element of the T3/S3 recommendation is flexibility allowing individual broadcasters or alternate media service providers to assign channel capacity as they see fit to video, audio and other services, while maintaining some minimum level of essential services, e.g., audio and captioning, as mandated by the FCC or voluntarily agreed to by the industry.

This flexibility requires that the transmitted digital data stream be broken into identifiable segments that can be assigned to video, audio, and various data services. There are many ways in which this can be done, and not all proponents do it identically. The segments have been called packets by some and virtual data streams by others. The means to identify the segments are called service identifiers by some and headers and descriptors by others. What they are called is not important; that they exist is. Furthermore the means used to identify a segment must be open-ended to permit new services to be implemented when they are thought of in the future.

### G. End-to-End Security

If conditional-access hardware were built into all ATV receivers, it would be possible to provide end-to-end security, since the digital baseband television signal would not be available in descrambled form at the baseband digital interface. Assuming that the baseband digital interface becomes the standard interface for ATV VCR's (as described above), it would be possible to record a scrambled program

only in scrambled form.<sup>4</sup> It would thus be possible to charge separately for each time the tape is played back. Also it would be possible to rent pre-recorded tapes that could not be usefully copied and that could be rented on a pay-per-view basis (separate charge for each play-back).

It is not necessary that all of the conditional-access hardware be built into the ATV receiver to achieve end-to-end security. Specifically it is sufficient that the portion of the hardware that accepts the seed, generates the pseudo-random number and performs the mathematical operation between the pseudo-random number and the scrambled source-coded digital signal be built into the ATV receiver. This portion of the conditional-access system would need to be standardized. The remainder of the conditional-access system could remain in a back-of-the-set box. It would obtain conditional-access data messages from the baseband digital interface and provide the seeds to the receiver through another interface specific to this purpose.

#### H. Digital Compressed NTSC

Although not a part of the FCC agenda for terrestrial broadcast ATV, it is clear that the same advances in compression technology that permit HDTV signals to be transmitted in a single 6-MHz channel permit a multiplicity of NTSC<sup>5</sup> signals to be transmitted in such a channel. Both Cable TV operators and DBS operators plan to use this capability to expand the number of channels they can offer to subscribers. Many of these channels will carry premium programming and will be scrambled. Initially, of course, set-top boxes will be used to descramble and decompress these signals providing an analog output (either RF or baseband) to feed the subscriber's existing NTSC receiver.

Assuming that both HDTV and multiple compressed digital NTSC services become and remain popular with the American public, it would be desirable to have as much commonality as possible in their implementations. For example, if the same basic compression algorithm and source-code format were to be used for both, then common receiver hardware could be used to decompress both HDTV and digital NTSC signals. The same advantages would obtain if a common conditional-access standard were used for both services. It should go without saying that the segmentation of the transmitted digital data stream and the means to identify the segments should also be common for both services.

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<sup>4</sup> In this case there might be problems with operating the VCR in trick modes.

<sup>5</sup> NTSC is used here to mean 525-line signals with NTSC resolution. The input to the compression encoder would likely be in component form rather than NTSC composite.

## **I. Related CCIR Activities**

CCIR Study Group 11 has considered the question of Conditional-Access Broadcasting (Question 37/11) and has produced a Draft New Recommendation [Doc. 11/66] Conditional-Access Broadcasting Systems.

## **IV. CONCLUSIONS**

T3/S2 has built its conclusions on the assumption that the FCC will choose an all-digital ATV system for terrestrial broadcasting. The FCC will, at a minimum, specify those parameters of the source-coding algorithm that could affect the ability of ATV receivers to decompress the recovered source-coded signal. The door should be left open to future improvements in the source-coding algorithm that will not affect existing ATV receivers. The FCC will also specify the channel-coding algorithm and modulation method for terrestrial broadcasting, possibly designating a system with optional broadcast coding such as 16 QAM/32 QAM, or a system with different optional coding for broadcast and Cable TV such as 4 VSB/16 VSB as suggested by some proponents. If options are allowed, all ATV receivers will be required to automatically recognize and process all optional formats. The FCC will also specify a means to segment the transmitted data stream and an open-ended scheme for identifying the contents of each segment. Finally, the FCC will designate minimum requirements for audio and certain data services, e.g., captioning.

ATV signals originated for Cable TV distribution only may differ slightly from broadcast ATV signals. For example, if the FCC allows only 4 VSB or 16 QAM for terrestrial broadcast, Cable TV could choose to use 16 VSB or 32 QAM transmission, but only if TV receiver manufacturers agree to build receivers that will automatically recognize and process either signal. In all likelihood, the source-coding and channel-coding algorithms and modulation method used for Cable TV signals will be identical to those used for terrestrial broadcast.

T3/S2 believes that the other alternate media (DBS, switched networks, Microwave Media, etc.) will employ the same source-coding algorithm as terrestrial broadcast, although they may use different channel-coding algorithms and modulation methods. The use of a different channel code and modulation method is certain to be the case for DBS and switched networks due to the different nature of the transmission medium. However, in all cases, after demodulation and error detection and correction, the recovered baseband, source-coded digital signals will share a common format, permitting decompression and display by any ATV receiver.

The use of a segmented data stream with segment identifiers will permit flexibility and extensibility. There are three generic classes of segments: video, audio and data. All ATV receivers will not process all segments. The simplest receivers will recognize



and process only the segments required to provide the manufacturer's intended level of video and audio quality, e.g., small-screen low-cost receivers with monophonic sound.

It is essential that all ATV receivers and VCR's be equipped with a baseband digital interface. The interface should be bi-directional with separate input and output connections. The signal present at the interface should be the source-coded digital signal recovered by the ATV receiver. The presence of the baseband digital interface is a necessary first step to achieving a single, conditional-access standard and even if such a standard cannot be agreed to, the baseband digital interface will provide a high degree of user-friendliness by eliminating the need for set-top converters.

T3/S2 concludes that there are no technical reasons to prevent the development and adoption of a single conditional-access standard for ATV. Scrambling the signal in the digital domain and the use of a replaceable security module makes it possible to meet all of the requirements for a conditional-access system. T3/S2 therefore believes that every effort should be made by the industry to agree to adopt a single voluntary conditional-access standard that can be used by all media to deliver premium ATV programming.

## V. RECOMMENDATIONS

T3/S2 makes the following specific recommendations with respect to interoperability and consumer product interface:

- All alternate media for the delivery of ATV programming should choose the same source-coding algorithm and baseband digital signal format chosen by the FCC for terrestrial broadcast.
- Alternate media should choose channel coding and modulation methods appropriate to the medium. In general these will be different from the channel coding and modulation methods chosen for terrestrial broadcast. In the case of Cable TV any departure from terrestrial broadcast must be for very good reason and with the concurrence of and agreement to support from television receiver manufacturers.
- Data services will vary from medium to medium. It is therefore extremely important that the transmitted digital data stream be divided into identifiable segments that can be flexibly assigned to video, audio and data services. There must be a defined open-ended scheme for identifying the individual segments to allow extensibility to implement new services in the future.
- The EIA should take to completion its work to develop a voluntary baseband bit-serial digital interface for ATV receivers and VCR's. This interface standard is an achievable key step to providing user friendliness and an important first step towards a voluntary conditional-access standard. This bi-directional interface would output

the baseband source-coded digital signal recovered by the receiver or VCR and accept a like signal as input.

- Strong consideration should be given to developing a single voluntary conditional-access standard that could be adopted for use by all media, including terrestrial broadcast. Such a standard would likely be implemented initially using back-of-the-set boxes and the baseband digital interface, but could lead to eventual inclusion of descrambling hardware in the ATV receiver. The standard would be based on secure scrambling of the baseband source-coded data stream and the use of a replaceable security module containing the key-processing algorithm and the subscriber secret address. There should be a standardized interface for the replaceable security module and the EIA should participate in developing the standard since the interface may eventually become part of an ATV receiver.
- The EIA should look to the day when part or all of the conditional-access hardware can be built into the ATV receiver or VCR and develop voluntary standards for the other required receiver interfaces, e.g., modem to order pay-per-view programs, etc.
- The EIA should also develop a voluntary standard for a control interface (possibly based on CEBus) to provide communication between ATV receivers and VCR's and peripheral devices such as Cable TV and DBS interfaces for such purposes as ordering pay-per-view programming.
- To achieve the necessary cooperation among industry segments to develop a single conditional-access standard, T3/S2 recommends that once the FCC has chosen a terrestrial broadcast ATV standard, the winning proponent should meet with representatives of the various transport media (Cable TV, DBS, etc.), manufactures, and other interested parties to seek agreement on an appropriate conditional-access standard.
- This same group should include standards for digital NTSC transmission as part of its agenda and, to the extent possible, seek to achieve commonality of compression and modulation methods as well as conditional access.